upon, for example by sending touch coordinates to the operating system. If, on the other hand, the touch is not confirmed, the touch is invalidated. The system can be designed such that there is a primary touch sensor that determines the touch coordinates and a secondary sensor that validates the presence of a touch, by either a discrete signal or by generating a second set of touch coordinates for comparison purposes. Furthermore, the touch coordinates can either be determined before or after the initial touch is confirmed. The combination of force and projective capacitive sensor systems is particularly well suited to meet the needs of demanding outdoor and semi-outdoor touch applications.

In one embodiment of the invention, projective-capacitive sensors are used as the primary sensor and one or more force sensors are used to obtain touch validation. In this embodiment the force sensor is used to determine when an object makes contact with the touch surface. Preferably the system is set-up to require that a certain pressure must be applied to the touchscreen in order to register a touch. Once the pressure on the touchscreen exceeds a predetermined threshold, the projective-capacitive sensor is queried to determine if it also detects a touch. If the projective-capacitive sensor does not detect a touch, the touch is invalidated and the system is placed back into a stand-by mode. If the projective-capacitive sensor does detect a touch, then position coordinates are determined. Additionally, in the preferred embodiment an untouch threshold is set. This threshold can be, for example, equal to a percentage of the projective-capacitive signal amplitude when the touch was first detected by the force sensor.

In another embodiment of the invention, multiple force sensors are used as the primary sensor to accurately determine touch position coordinates while a projective-capacitive sensor is used as the secondary sensor to validate a touch detected by the primary sensor. In this embodiment, since the projective-capacitive sensor is only used for touch confirmation, it can utilize very few electrodes, thereby minimizing both touchscreen fabrication complexity and the number of required electronic channels. In this embodiment after a touch is detected by the force sensors, the projective-capacitive sensor is queried to determine whether the touch was due to a conductive and grounded object. If the touch is validated, touch position coordinates are generated by the primary sensor and the system is returned to stand-by mode. In its simplest configuration, if the touch is invalidated the system is simply returned to stand-by mode without determining touch coordinates or reporting any coordinates to the operating system. In an alternate configuration, if the touch is invalidated, the pressure threshold of the force sensors is adjusted to minimize further false touches.

In another embodiment of the invention, projective-capacitive and force sensors are utilized, both of which are capable of providing accurate touch position coordinates. In this embodiment the system is designed to determine which sensor is most likely to provide accurate position coordinates for a given set of conditions.

A further understanding of the nature and advantages of the present invention may be realized by reference to the remaining portions of the specification and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a flow chart illustrating the basic methodology of the present invention;

FIG. **2** is a flow chart illustrating an alternate methodology of the present invention;

FIG. **3** is an illustration of a force sensor;

FIG. **4** is an illustration of one or more force sensors applied to a touchscreen;

FIG. **5** is an illustration of a projective-capacitive touch sensor;

FIG. **6** is a cross-sectional view of the projective-capacitive touch sensor shown in FIG. **5**;

FIG. **7** is an illustration of an embodiment utilizing a projective-capacitive sensor as the primary sensor and one or more force sensors as the secondary sensor;

FIG. **8** is a flow chart illustrating the preferred method of using the embodiment illustrated in FIG. **7**;

FIG. **9** is an illustration of an embodiment utilizing multiple force sensors as the primary sensor and a projective-capacitive sensor as the secondary sensor;

FIG. **10** is a flow chart illustrating the preferred method of using the embodiment illustrated in FIG. **9**;

FIG. **11** is a flow chart illustrating the method used with an embodiment of the invention in which both the projective-capacitive and force touch sensors provide touch position coordinates;

FIG. **12** is an illustration of a generic block circuit diagram for a sensor element readout circuit;

FIG. **13** is an illustration of a projective-capacitive sensor element for use with the circuit of FIG. **12**; and

FIG. **14** is an illustration of a force sensor element for use with the circuit of FIG. **12**.

DESCRIPTION OF THE SPECIFIC EMBODIMENTS

FIG. **1** is a flow chart illustrating the preferred operation of the present invention. At step **101**, the touchscreen is in a pre-touch, stand-by status. The screen then receives a touch (step **103**), for example via a finger, perhaps gloved. The primary touch sensor then registers a touch (step **105**). Prior to the primary touch sensor determining the coordinates of the touch or sending any information to the operating system (e.g., touch position, touch mode, etc.), a secondary sensor confirms that the touch received by the primary sensor is a valid touch (step **107**). If the secondary sensor confirms that the touch is valid (step **109**), the touch position coordinates are determined (step **111**). Depending upon the desired configuration, the coordinates of the touch position can be determined by either the primary sensor or the secondary sensor. The touch controller then sends the touch information (e.g., touch position coordinates) to the operating system (step **113**). If the secondary sensor does not confirm that a valid touch was received by the primary sensor, no touch information is sent to the operating system and the touch sensor is placed back into stand-by status **101**. The benefit of this embodiment is that time is not spent on determining invalid touch positions, thus enabling the system to quickly confirm that a valid touch has been received and if the touch is invalidated, to quickly return to stand-by status **101**.

In a slight modification of the system illustrated in FIG. **2**, after the primary sensor registers a touch (step **105**), it determines the position of the touch (step **201**). After determining touch position, the system can simply query the secondary sensor to determine it has also registered a touch (step **107**) and if it has, confirm the touch (step **109**) and send the position coordinates to the operating system (step **203**). Alternately, after the touch position has been determined (step **201**), a coordinate dependent touch threshold is set for the secondary sensor (step **205**), thus accounting for coordinate dependent touch sensitivities.